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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/043,225	01/14/2002	Masamoto Tago	Q67964	4956

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EXAMINER	
PAREKH, NITIN	

ART UNIT	PAPER NUMBER
2811	

DATE MAILED: 08/18/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/043,225	TAGO ET AL.	
	Examiner	Art Unit	
	Nitin Parekh	2811	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *22 June 2004*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-162* is/are pending in the application.

4a) Of the above claim(s) *57-157* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-56 and 158-162* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *21 April 2003* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *11*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Request for Continued Examination

1. A request for continued examination (RCE) under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 06/22/04 has been entered. An action on the RCE follows.

2. The amendment filed on 05/12/2004 has been entered.

Information Disclosure Statement

3. The Information Disclosure Statement filed on 03-22-04 has been considered.

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

5. Claims 1, 3, 5, 7, 9, 11, 21, 22, 25, 26, 29-33, 39-43, 158, 159 and 161 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marlin (US Pat. 6429046) in view of Chan et al. (US Pat. 5471092).

Regarding claims 1, 158 and 159, Marlin discloses a semiconductor device (100 in Fig. 5) having an electrode structure comprising a solder bump (310 in Fig. 5) formed of an alloy solder without lead, the alloy solder including tin-silver (SnAg- Col. 2, line 19), the Sn and Ag being a first and second main components of the alloy respectively on a underbump metallurgy (UBM) structure on a wiring/power layer (104 in Fig. 5), the device further comprising:

- the bump having a stud/support comprising copper (see 308 in Fig. 5; Col. 2, line 60)
- an underbump layer (UBL-302 in Fig. 5; Col. 2, line 30) comprising an electrically conductive nonwettable material such as titanium (Ti) or titanium-tungsten (TiW) alloy (302 in Fig. 5; Col. 2, lines 15-30), and
- a final structure having the solder ball/reflowed solder ball (310 in Fig. 6) being formed on the UBL and the wiring/power layer

(Fig. 3-6; Col. 2, line 5- Col. 3, line 20).

Marlin fails to teach an intermetallic compound being formed between the solder bump and the UBL, the intermetallic compound including a metal that is a main component of the alloy solder and a second metal different from that of the metal of the main component and that of the UBL.

Chan et al. teach a solder ball/UBL reflow structure where an intermetallic compound including metals such as tin (Sn) and copper (Cu) is formed after solder reflow of tin based alloy solder having tin as a main component on a metal/solder reactive layer comprising copper (38 and 42 respectively in Fig. 2 and 3; Col. 3, lines 20-56) to prevent formation of the intermetallics in the underlying layers, improve adhesion and to reduce the joint stress (Col. 3, line 10-56), the intermetallic compound/Cu-Sn including the main component/metal (Sn) of the alloy solder and the second metal such as Cu, which is different than the main component of the alloy solder and also being different from the metal of the UBL such as Ti or W (Col. 3-6).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate an intermetallic compound being formed between the solder bump and the UBL, the intermetallic compound including a metal that is a main component of the alloy solder and a second metal different from that of the main component and that of the UBL as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 5, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 1 above, wherein Martin further teaches the tin being the main component of the SnAg alloy solder (Col. 2, line 19).

Regarding claim 9, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 1 and 5 above, wherein Martin further teaches silver being the second main component of the alloy solder after tin (Col. 2, line 19).

Regarding claims 21 and 22, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 1 above, except the second metal, which is different from the first metal is allowed to form an intermetallic compound with tin and copper.

Chan et al. further teach the intermetallic compound (Sn-Cu) being formed/allowed to be formed with Sn and the second metal such as Cu (Col. 3, lines 10-56), which is different from the first metal such as nickel.

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate a second metal being allowed to form an intermetallic compound with tin where second metal different from the first metal as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claims 29 and 30, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 1 above, except the UBL including nickel (Ni) or being a laminated film formed from one of the nickel and nickel alloy with different film qualities.

Chan et al. further teach using a Ni layer/alloy (42 in Fig. 3) as an UBL where the layer/alloy is selected to include Ni, nickel-phosphorous (NiP) having different film qualities or the combination/lamination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 31, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 1 and 29 above, except the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include one or more layers/lamination of material such as Ni, Cu, NiP alloy, etc. (Col. 4, line 31) to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claims 32 and 33, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 1 and 29-31 above, except the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, NiP or the combination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

A. Regarding claims 3 and 161, Marlin discloses a semiconductor device (100 in Fig. 5) having an electrode structure comprising a solder bump (310 in Fig. 5) formed of an alloy solder without lead, the alloy solder including tin-silver (SnAg- Col. 2, line 19), the Sn and Ag being a first and second main components of the alloy respectively on a underbump metallurgy (UBM) structure on a wiring/power layer (104 in Fig. 5), the device further comprising:

- the bump having a stud/support comprising copper (see 308 in Fig. 5; Col. 2, line 60)
- an underbump layer (UBL-302 in Fig. 5; Col. 2, line 30) comprising an electrically conductive nonwettable material such as titanium (Ti) or titanium-tungsten (TiW) alloy (302 in Fig. 5; Col. 2, lines 15-30), and
- a final structure having the solder ball/reflowed solder ball (310 in Fig. 6) being formed on the UBL and the wiring/power layer

(Fig. 3-6; Col. 2, line 5- Col. 3, line 20).

Marlin fails to teach an intermetallic compound being formed between the solder bump and the UBL, the intermetallic compound including a metal that is a main component of the alloy solder and a second metal different from that of the metal of the main component and that of the UBL.

Chan et al. teach a solder ball/UBL reflow structure where an intermetallic compound including metals such as tin (Sn) and copper (Cu) is formed after solder reflow of tin based alloy solder having tin as a main component on a metal/solder reactive layer comprising copper (38 and 42 respectively in Fig. 2 and 3; Col. 3, lines 20-56) to prevent formation of the intermetallics in the underlying layers, improve adhesion and to reduce the joint stress (Col. 3, line 10-56), the intermetallic compound/Cu-Sn including the main component/metal (Sn) of the alloy solder and the second metal such as Cu, which is different than the main component of the alloy solder and also being different from the metal of the UBL such as Ti or W (Col. 3-6).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate an intermetallic compound being formed between the solder bump and the UBL, the intermetallic compound including a metal that is a main component of the alloy solder and a second metal different from that of the main component and that of the UBL as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

B. Regarding claim 3, temporarily arranging a second metal layer on the underbump layer and then dissolving into the alloy solder on formation of the solder bump do not distinguish over Marlin and Chan et al., because only the final product/structure is relevant, not the process of making such as "temporarily arranging and dissolving" or

"laminating and hot pressing or fusing". Note that a "product by process" claim is directed to the product per se, no matter how actually made, In re Hirao, 190 USPQ 15 at 17 (footnote 3). See also In re Brown, 173 USPQ 685; In re Luck, 177 USPQ 523; In re Fessmann, 180 USPQ 324; In re Avery, 186 USPQ 161; In re Wertheim, 191 USPQ 90 (209 USPQ 554 does not deal with this issue); and In re Marrosi et al., 218 USPQ 289, all of which make it clear that it is the patentability of the final product per se which must be determined in a "product by process" claim, and not the patentability of the process, and that an old or obvious product produced by a new method is not patentable as a product, whether claimed in "product by process" claims or not . Note that applicant has the burden of proof in such cases, as the above case law makes clear. See also MPEP 706.03(e).

Regarding claim 7, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 3 above, wherein Martin further teaches the tin being the main component of the SnAg alloy solder (Col. 2, line 19).

Regarding claim 11, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 3 and 7 above, wherein Martin further teaches silver being the second main component of the alloy solder after tin (Col. 2, line 19).

Regarding claims 25 and 26, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 3 above, except the second metal, which is different from the first metal is allowed to form an intermetallic compound with tin.

Chan et al. further teach the intermetallic compound (Sn-Cu) being formed/allowed to be formed with Sn and the second metal such as Cu, which is different from the first metal such as nickel (Col. 3, lines 10-56).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate a second metal being allowed to form an intermetallic compound with tin where second metal different from the first metal as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claims 39 and 40, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 1 above, except the UBL including nickel (Ni) or being a laminated film formed from one of the nickel and nickel alloy with different film qualities.

Chan et al. further teach using a Ni layer/alloy (42 in Fig. 3) as an UBL where the layer/alloy is selected to include Ni, nickel-phosphorous (NiP) having different film qualities or the combination/lamination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 41, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 3 and 39 above, except the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include one or more layers/lamination of material such as Ni, Cu, NiP alloy, etc. (Col. 4, line 31) to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claims 42 and 43, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 3 and 39-41 above, except the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, NiP or the combination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

6. Claims 2, 4, 6, 8, 10, 12, 23, 24, 27, 28, 34-38, 44-48, 55, 56, 160 and 162 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marlin (US Pat. 6429046) in view of Chan et al. (US Pat. 5471092) and Darveaux et al. (US Pat. 6201305).

Regarding claims 2, 160 and 162, Marlin discloses a semiconductor device (100 in Fig. 5) having an electrode structure comprising a solder bump (310 in Fig. 5) formed of an alloy solder without lead, the alloy solder including tin-silver (SnAg- Col. 2, line 19), the

Sn and Ag being a first and second main components of the alloy respectively on a underbump metallurgy (UBM) structure on a wiring/power layer (104 in Fig. 5), the device further comprising:

- the bump having a stud/support comprising copper (see 308 in Fig. 5; Col. 2, line 60)
- an underbump layer (UBL-302 in Fig. 5; Col. 2, line 30) comprising an electrically conductive nonwettable material such as titanium (Ti) or titanium-tungsten (TiW) alloy (302 in Fig. 5; Col. 2, lines 15-30), and
- a final structure having the solder ball/reflowed solder ball (310 in Fig. 6) being formed on the UBL and the wiring/power layer

(Fig. 3-6; Col. 2, line 5- Col. 3, line 20).

Marlin fails to teach an alloy layer composed of a combination of intermetallic compound being formed between the solder bump and the UBL, the combination including:

a) the intermetallic compound including a metal that is a main component of the alloy solder and a second metal different from that of the metal of the main component and that of the UBL, and

b) an intermetallic compound of the first metal included in the UBL and the metal that is the main component of the alloy solder.

a) Chan et al. teach a solder ball/UBL reflow structure where an intermetallic compound including metals such as tin (Sn) and copper (Cu) is formed after solder reflow of tin based alloy solder having tin as a main component on a metal/solder reactive layer comprising copper (38 and 42 respectively in Fig. 2 and 3; Col. 3, lines 20-56) to prevent formation of the intermetallics in the underlying layers, improve adhesion and to reduce the joint stress (Col. 3, line 10-56), the intermetallic compound/Cu-Sn including the main component/metal (Sn) of the alloy solder and the second metal such as Cu, which is different than the main component of the alloy solder and also being different from the metal of the UBL such as Ti or W (Col. 3-6).

b) Darveaux et al. teach a solder ball mounting structure (Fig. 2A/2B) having underbump layer such as nickel on a laminated pad (28 in Fig. 2A/2B; Col. 3, line 57) where an intermetallic compound such as tin-nickel (SnNi) is formed, the intermetallic compound including the metal/first metal such as nickel and the main component of the alloy of the solder ball such as tin (Col. 3, line 55- Col. 4, line 7).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate elements a) and b) as taught by Chan et al. and Darveaux et al. so that formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 6, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 2 above, wherein Martin further teaches the tin being the main component of the SnAg alloy solder (Col. 2, line 19).

Regarding claim 10, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 2 and 6 above, wherein Martin further teaches the silver being the second main component of the alloy solder after tin (Col. 2, line 19).

Regarding claims 23 and 24, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 2 above, except the second metal, which is different from the first metal is allowed to form an intermetallic compound with tin.

Chan et al. further teach the intermetallic compound (Sn-Cu) being formed/allowed to be formed with Sn and the second metal such as Cu, which is different from the first metal such as nickel (Col. 3, lines 10-56).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate a second metal being allowed to form an intermetallic compound with tin where second metal different from the first metal as taught by Chan et al. so that formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claims 34 and 35, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 2 above, except the UBL including nickel (Ni) or being a laminated film formed from one of the nickel and nickel alloy with different film qualities.

Chan et al. further teach using a Ni layer/alloy (42 in Fig. 3) as an UBL where the layer/alloy is selected to include Ni, nickel-phosphorous (NiP) having different film qualities or the combination/lamination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Chan et al. and Darveaux et al. and Marlin's solder bump device.

Regarding claim 36, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 2 and 34 above, except the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include one or more layers/lamination of material such as Ni, Cu, NiP alloy, etc. (Col. 4, line 31) to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claims 37 and 38, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 2 and 34-36 above, except the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, NiP or the combination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi)

alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

A. Regarding claims 4 and 162, Marlin discloses a semiconductor device (100 in Fig. 5) having an electrode structure comprising a solder bump (310 in Fig. 5) formed of an alloy solder without lead, the alloy solder including tin-silver (SnAg- Col. 2, line 19), the

Sn and Ag being a first and second main components of the alloy respectively on a underbump metallurgy (UBM) structure on a wiring/power layer (104 in Fig. 5), the device further comprising:

- the bump having a stud/support comprising copper (see 308 in Fig. 5; Col. 2, line 60)
- an underbump layer (UBL-302 in Fig. 5; Col. 2, line 30) comprising an electrically conductive nonwettable material such as titanium (Ti) or titanium-tungsten (TiW) alloy (302 in Fig. 5; Col. 2, lines 15-30), and
- a final structure having the solder ball/reflowed solder ball (310 in Fig. 6) being formed on the UBL and the wiring/power layer

(Fig. 3-6; Col. 2, line 5- Col. 3, line 20).

Marlin fails to teach an alloy layer composed of a combination of intermetallic compound being formed between the solder bump and the UBL, the combination including:

a) the intermetallic compound including a metal that is a main component of the alloy solder and a second metal different from that of the metal of the main component and that of the UBL, and

b) an intermetallic compound of the first metal included in the UBL and the metal that is the main component of the alloy solder.

a) Chan et al. teach a solder ball/UBL reflow structure where an intermetallic compound including metals such as tin (Sn) and copper (Cu) is formed after solder reflow of tin based alloy solder having tin as a main component on a metal/solder reactive layer comprising copper (38 and 42 respectively in Fig. 2 and 3; Col. 3, lines 20-56) to prevent formation of the intermetallics in the underlying layers, improve adhesion and to reduce the joint stress (Col. 3, line 10-56), the intermetallic compound/Cu-Sn including the main component/metal (Sn) of the alloy solder and the second metal such as Cu, which is different than the main component of the alloy solder and also being different from the metal of the UBL such as Ti or W (Col. 3-6).

b) Darveaux et al. teach a solder ball mounting structure (Fig. 2A/2B) having underbump layer such as nickel on a laminated pad (28 in Fig. 2A/2B; Col. 3, line 57) where an intermetallic compound such as tin-nickel (SnNi) is formed, the intermetallic

compound including the metal/first metal such as nickel and the main component of the alloy of the solder ball such as tin (Col. 3, line 55- Col. 4, line 7).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate elements a) and b) as taught by Chan et al. and Darveaux et al. so that formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

B. Regarding claim 4, temporarily arranging a second metal layer on the underbump layer and then dissolving into the alloy solder on formation of the solder bump do not distinguish over Marlin, Chan et al. and Darveaux et al., because only the final product/structure is relevant, not the process of making such as "temporarily arranging and dissolving" or "laminating and hot pressing or fusing". Note that a "product by process" claim is directed to the product per se, no matter how actually made, In re Hirao, 190 USPQ 15 at 17 (footnote 3). See also In re Brown, 173 USPQ 685; In re Luck, 177 USPQ 523; In re Fessmann, 180 USPQ 324; In re Avery, 186 USPQ 161; In re Wertheim, 191 USPQ 90 (209 USPQ 554 does not deal with this issue); and In re Marrosi et al., 218 USPQ 289, all of which make it clear that it is the patentability of the final product per se which must be determined in a "product by process" claim, and not the patentability of the process, and that an old or obvious product produced by a new method is not patentable as a product, whether claimed in "product by process" claims

or not . Note that applicant has the burden of proof in such cases, as the above case law makes clear. See also MPEP 706.03(e).

Regarding claim 8, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 4 above, wherein Martin further teaches the tin being the main component of the SnAg alloy solder (Col. 2, line 19).

Regarding claim 12, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 4 and 8 above, wherein Martin further teaches the silver being the second main component of the alloy solder after tin (Col. 2, line 19).

Regarding claims 27 and 28, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 4 above, except the second metal, which is different from the first metal is allowed to form an intermetallic compound with tin.

Chan et al. further teach the intermetallic compound (Sn-Cu) being formed/allowed to be formed with Sn and the second metal such as Cu, which is different from the first metal/nickel (Col. 3, lines 10-56).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate a second metal being allowed to form an intermetallic compound with tin where second metal different from the first metal as

taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claims 44 and 45, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 4 above, except the UBL including nickel (Ni) or being a laminated film formed from one of the nickel and nickel alloy with different film qualities.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, nickel-phosphorous (NiP) having different film qualities or the combination/lamination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claim 46, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 4 and 44 above, except the UBL being a

laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include one or more layers/lamination of material such as Ni, Cu, NiP alloy, etc. (Col. 4, line 31) to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claims 47 and 48, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 4 and 44-46 above, except the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, NiP or the combination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the nickel alloy including one selected from a group

consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

7. Claims 13, 15, 17, 19, 49, 50, 53 and 54 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marlin (US Pat. 6429046) and Chan et al. (US Pat. 5471092) as applied to claims 1, 5 and 9 above, and further in view of Andricacos et al. (US Pat. 6224690).

Regarding claims 13 and 17, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 1, 5 and 9 above, except adding copper to the alloy solder.

Andricacos et al. teach using tin based solders having a variety of compositions including Sn-Ag solder having metals such as copper, nickel, etc. (see Table I, Col. 6) being added to achieve the desired melting range and improved wetting/flow properties (Col. 5, line 65- Col. 6, line 50).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to add copper to the alloy solder as taught by Andricacos et al. so

that the desired melting range can be achieved and the wetting/flow properties can be improved in Chan et al. and Marlin's solder bump device.

Regarding claims 15 and 19, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 3, 7 and 11 above, except adding copper to the alloy solder.

Andricacos et al. teach using tin based solders having a variety of compositions including Sn-Ag solder having metals such as copper, nickel, etc. (see Table I; Col. 6) being added to achieve the desired melting range and improved wetting/flow properties (Col. 5, line 65- Col. 6, line 50).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to add copper to the alloy solder as taught by Andricacos et al. so that the desired melting range can be achieved and the wetting/flow properties can be improved in Chan et al. and Marlin's solder bump device.

Regarding claims 49, 50, 53 and 54, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 1 and 3 above, except providing a contact layer between the wiring layer and UBL, the contact layer including one of Ti and TiW alloy.

Andricacos et al. teach using conventional adhesion/contact/barrier layers such as TiW between the wiring layer and UBL (not numerically referenced- see

adhesion/barrier layer between contact/wiring and barrier/glue UBL in Fig. 1; Col. 2, lines 45-53).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to provide the contact layer between the wiring layer and UBL, the contact layer including one of Ti and TiW-alloy as taught by Andricacos et al. so that the contact/adhesion can be improved in Chan et al. and Marlin's solder bump device.

8. Claims 14, 18, 51, 52, 55 and 56 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marlin (US Pat. 6429046), Chan et al. (US Pat. 5471092) and Darveaux et al. (US Pat. 6201305) as applied to claims 2, 6 and 10 above, and further in view of Andricacos et al. (US Pat. 6224690).

Regarding claims 14 and 18, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 2, 6 and 10 above, except adding copper to the alloy solder.

Andricacos et al. teach using tin based solders having a variety of compositions including Sn-Ag solder having metals such as copper, nickel, etc. (see Table I, Col. 6) being added to achieve the desired melting range and improved wetting/flow properties (Col. 5, line 65- Col. 6, line 50).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to add copper to the alloy solder as taught by Andricacos et al. so

that the desired melting range can be achieved and the wetting/flow properties can be improved in Darveaux et al., Chan et al. and Marlin's solder bump device.

Regarding claims 51, 52, 55 and 56, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 2 and 4 above, except providing a contact layer between the wiring layer and UBL, the contact layer including one of Ti and TiW alloy.

Andricacos et al. teach using conventional adhesion/contact/barrier layers such as TiW between the wiring layer and UBL (not numerically referenced- see adhesion/barrier layer between contact/wiring and barrier/glue UBL in Fig. 1; Col. 2, lines 45-53).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to provide the contact layer between the wiring layer and UBL, the contact layer including one of Ti and TiW alloy as taught by Andricacos et al. so that the contact/adhesion can be improved in Chan et al. and Marlin's solder bump device.

9. Claims 16 and 20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marlin (US Pat. 6429046), Chan et al. (US Pat. 5471092) and Darveaux et al. (US Pat. 6201305) as applied to claims 4, 8 and 12 above, and further in view of Andricacos et al. (US Pat. 6224690).

Regarding claims 16 and 20, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 4, 8 and 12 above, except adding copper to the alloy solder.

Andricacos et al. teach using tin based solders having a variety of compositions including Sn-Ag solder having metals such as copper, nickel, etc. (see Table I, Col. 6) being added to achieve the desired melting range and improved wetting/flow properties (Col. 5, line 65- Col. 6, line 50).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to add copper to the alloy solder as taught by Andricacos et al. so that the desired melting range can be achieved and the wetting/flow properties can be improved in Darveaux et al., Chan et al. and Marlin's solder bump device.

Response to Arguments

10. Applicant's arguments filed on 06-22-04 have been fully considered but they are not persuasive.

A. Applicant contends that it is not clear from the combination of Marlin and Chan et al., how the intermetallic compound is formed including a metal that is a main component of the alloy solder and a second metal different from that of the metal of the main component and that of the UBL.

However, as explained above, as shown in the final structure in Marlin (see Fig. 6), the solder bump comprises elements including tin and copper (see 310/308 in Fig. 6; Col. 2, lines 19 and 60) and the UBL comprising Ti or TiW (302 in Fig. 6). Chan et al. teach the intermetallic compound including Sn and Cu being is formed after solder reflow of tin based alloy solder (Col. 3, lines 20-56). Such the intermetallic compound/Cu-Sn includes the main component/Sn of the alloy solder and the second metal such as Cu, which is different than the main component of the alloy solder and also being different from the metal of the UBL such as Ti or W.

B. Applicant contends that the applied references do not teach the alloy solder containing no lead.

However, as explained above, Marlin teaches the solder bump being formed of a variety of alloys including the alloy containing no lead such as Sn-Ag alloy (Col. 2, line 19).

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Nitin Parekh whose telephone number is 571-272-1663. The examiner can normally be reached on 09:00AM-05:30PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Eddie Lee can be reached on 571-272-1732. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9318.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

NP

08-14-04

NITIN PAREKH

PATENT EXAMINER

TECHNOLOGY CENTER 2800